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Reconfigurable Tactical Operations Simulator (RTOS) Operational Demonstration in 5-52 Air Defense Artillery

by John K. Hawley, Anna L. Mares, John I. Fallin, and Chad Wallet

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14. ABSTRACT
During the combat operations phase of Operation Iraqi Freedom (OIF), Patriot air and missile defense units were involved in two fratricide incidents involving coalition aircraft. Patriot's unacceptable fratricide rate during OIF (18% of engagements) prompted the commanding general of the Army Air and Missile Defense Center to request a human-performance-oriented assessment of the fratricide incidents to complement the official Army board if inquiry investigation. This report summarizes the results and recommendations from that assessment. Recommendations for a solution to the fratricide problem involved both command and control and training modifications. The paper's primary focus is the demonstration and evaluation of modified training practices in an operational Patriot unit, 5-52 Air Defense Artillery (ADA). Specific aspects of these modified training practices included (1) the use of a less-than-full fidelity training device to supplement the unit's organic embedded training capability (the Reconfigurable Tactical Operations Simulator, or RTOS) coupled with (2) a performance-oriented instructional strategy focused on deliberate practice. The conduct of the operational demonstration in 5-52 ADA is described and results are reported. Results obtained from the demonstration included (1) an RTOS utility assessment, (2) pre- versus post-training results for trial instructional modules, and (3) participant comments. Demonstration results are discussed in terms of the literature on simulation and training effectiveness. Recommendations for extending the scope of the demonstration to include a more intensive study of training effectiveness and transfer of learning also are provided.

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1. Introduction

1.1 Background

During the combat operations phase of Operation Iraqi Freedom (OIF)—March-April 2003, U.S. Army Patriot air and missile defense (AMD) units were involved in two fratricide incidents. In the first, a British Tornado was misclassified as an anti-radiation missile (ARM) and subsequently engaged and destroyed. The second fratricide incident involved a Navy F/A-18 that was misclassified as a tactical ballistic missile (TBM) and also engaged and destroyed. Three flight crew members lost their lives in these incidents. OIF involved a total of 11 Patriot engagements by U.S. units. Of these 11, nine resulted in successful TBM engagements; the other two (18%) were fratricides.

In the spring of 2004, a team from the Army Research Laboratory's Human Research and Engineering Directorate (ARL HRED) began looking into Patriot performance and training issues at the invitation of the then Ft. Bliss Commander, Major General (MG) Michael A. Vane. After reviewing the conclusions of the various boards of inquiry formed to look into the OIF fratricides, MG Vane was convinced that human performance issues were part of the problem leading to those incidents. He was particularly concerned by what he termed a "lack of vigilance" on the part of Patriot operators along with an apparent "lack of cognizance" of what was being presented to them on situation displays with a resulting "absolute trust in automation." Accordingly, he requested that HRED conduct a human-performance-oriented critical incident assessment to complement the board of inquiry investigations and report back to him regarding potential problems and solutions.

HRED's project team spent most of the summer and fall of 2004 performing the requested human-performance-oriented critical incident assessment of the OIF fratricides. An initial assessment was delivered to MG Vane in October 2004. HRED's report to MG Vane recommended two primary actionable items to redress the performance problems identified during the Patriot Vigilance effort:

1. Re-examine automation concepts, operator roles, and command and control (C2) relationships in AMD battle command systems to emphasize effective human supervisory control; and

2. Develop more effective missile crews and C2 teams, particularly with respect to Air Defense Operations—re-look the level of *expertise* required to operate such a lethal system on the modern battlefield.

In present usage, the term effective human supervisory control refers to a situation in which Soldiers and not the automated system are the ultimate decision makers in AMD firing decisions. Uncritical acquiescence to the automated system's recommendations is not effective human supervisory control.

In a report on Patriot system performance requested by the Under Secretary of Defense for Acquisition, Technology, and Logistics, the Defense Science Board reinforced HRED's recommendations with the following comments (Defense Science Board, 2004). Although the full report is classified, these extracts are not.

> The Patriot system should migrate to more of a "man-in-the-loop" philosophy versus a fully automated philosophy—providing operator awareness and control of engagement processes.

and

> Patriot training and simulations should be upgraded to support this man-in-the-loop protocol including the ability to train on confusing and complex scenarios that contain unbriefed surprises.

A summary of the report on Patriot system performance is available for download on the Defense Science Board web site. Readers should note that the report's recommendations closely parallel HRED's actionable items, and both address the need for AMD training modifications.

In addition to the briefing to MG Vane, the initial phase of the Patriot Vigilance project also resulted in an ARL technical report titled *The Human Side of Automation: Lessons for Air Defense Command and Control* (Hawley, Mares, & Giammanco, 2005). After reviewing results from the first phase of the project, the TRADOC Capability Manager (TCM) for Lower Tier AMD systems requested that the Patriot Vigilance project continue into a second year. The TCM specifically requested that HRED's project staff expand on the material presented in Hawley, Mares, and Giammanco (2005) and prepare two, more-detailed reports, one concerned with design for effective human supervisory control and a second addressing training for the emerging class of AMD systems. The intent of these reports was to inform the AMD community on "what right looks like" in each of these topic areas. The results were the two reports: *Developing Effective Human Supervisory Control for Air and Missile Defense Systems* (Hawley & Mares, 2006), and *Training for Effective Human Supervisory Control of Air and Missile Defense Systems* (Hawley, Mares, & Giammanco, 2006).

In the late summer of 2005 after MG Vane had left Ft. Bliss for another assignment, the project staff briefed his replacement, MG (then Brigadier General) Robert P. Lennox, on the status and results of the Patriot Vigilance project. MG Lennox formally requested that the project be continued for at least another year so that the technical staff could work with the AMD community on implementing selected results. HRED's project staff also would participate as the MANPRINT (Manpower and Personnel Integration) evaluator during a Limited User Test of the

Post-Deployment Build 6 (PDB-6) software suite for the Patriot system. PDB-6 was developed to address many of the Patriot system's operational deficiencies that had surfaced during OIF and were generally considered to have contributed to the unacceptable fratricide rate.

From the Fall of 2005 through the Summer of 2006 during the New Equipment Training (NET) and unit train-up period for the PDB-6 Limited User Test, the HRED project staff's observations regarding the progress of training for the test unit sounded an alarm bell loudly. PDB-6 training was not progressing as it should have. Training events were being completed, but individual and crew performance objectives were *not* being met. Many of the training issues identified and discussed in Hawley, Mares, and Giammanco (2006) were surfacing and were not being addressed adequately by the NET process or follow-on collective training by the test unit. Moreover, inadequate unit training showed up clearly in the ensuing test results.

The Army Evaluation Center's System Assessment Report resulting from the PDB-6 Limited User Test concluded that the level of expertise required to employ the Patriot system properly with PDB-6 software had exceeded the current Army training standard. An earlier Army board of inquiry report on the OIF fratricides had reached a similar conclusion, noting that "the system [Patriot] is too lethal to be placed in the hands of crews trained to such a limited standard." This convergence of evidence supported the conclusion that modifications to current AMD training practices were required. Moreover, these modifications would require not simply more "traditional" training, but performance-oriented strategies focused on deliberate practice (Hawley & Mares, 2007). Deliberate practice denotes a hands-on instructional regimen focused on specific instructional objectives accompanied by immediate and expert feedback (Ericsson & Charness, 1994). Frequent deliberate practice has been found to satisfy a primary condition for the development of high levels of job expertise (Ericsson, Krampe, & Tesch-Romer, 1993).

1.2 The Reconfigurable Tactical Operations simulator (RTOS) Operational Demonstration

After reviewing results from the OIF boards of inquiry, OIF training-related lessons learned, conclusions from HRED's Patriot Vigilance project, and results from the PDB-6 Limited User Test, the Army Air Defense Artillery (ADA) School's Directorate of Training, Doctrine, and Leader Development (DOTD-LD) concurred that a reexamination of AMD training practices and strategies was required. In addition to general agreement that a change in training rigor and instructional strategies was necessary, DOTD-LD identified a further training capability gap across AMD forces. This gap concerned the organic simulation capability available to AMD units. Their conclusion was that units required a capability to train fire control crews across the entire AMD kill chain that:

1. Supplemented units' organic embedded training (ET) capability;
2. Did not require use of tactical equipment; and

3. Could be conducted in an environment conducive to teambuilding, coaching, teaching, and mentoring. That is, a capability that should be used to support a performance-oriented instructional strategy focused on deliberate practice.

The School's interest in an enhanced simulation capability to supplement ET on tactical equipment was initiated by an Operational Needs Statement produced by the 35th ADA Brigade in Korea.

The ADA School's concern for an enhanced unit training capability was heightened by that fact that upcoming Base Realignment and Closure (BRAC) moves of AMD units away from Ft. Bliss will amplify the training capability gap by denying units ready access to Ft. Bliss' institutional (such as the Patriot Conduct of Fire Trainers, or PCOFTs) and post-wide training resources (such as the Drive Up Simulation and Training facility).

DOTD-LD identified an existing device, the Reconfigurable Tactical Operations Simulator (RTOS), as potentially fulfilling the need for a simulation capability to supplement units' organic ET capability, while not requiring the use of tactical equipment. RTOS hardware is commercial off the shelf (COTS), with the software being owned by the Army. The device has been in use since the late 1970s to support major air defense exercises as well as higher level experimentation and analysis. However, prior to the current project, the RTOS had not been used as a training device.

As a trainer, RTOS is an exemplar of a medium- to high-fidelity, part-task training device for AMD air battle operations. The term *medium-to high-fidelity* means the RTOS is not an exact *physical* replica of the Patriot system, and that its *functional* characteristics are not identical to those of the tactical system. Table 1 presents and defines a set of terms commonly used to describe simulators and simulations. *Part-task* means that the RTOS *does not* support all AMD air battle operations tasks. The term *reconfigurable* means that the RTOS' physical features (e.g., displays and controls) are not hard-manufactured or hard-wired into the device. Rather, displays are software driven and controls are implemented either using a mouse or a touch-sensitive screen. The original intent behind the RTOS was that any potential AMD system or system modification could be mocked-up readily and used in demonstrations or experiments. A more complete description of the RTOS and its capabilities is provided in appendix A.

Less-than-full-fidelity training devices such as the RTOS are commonly used in aviation and in other training applications (see, for example, Johnson & Stewart, 2005). Because of their relatively low cost versus full-fidelity training equipment, devices such as the RTOS have been found to be particularly useful in supporting essential skills integration (e.g., learning decision processes that underlie weapons system use) before moving to more costly and limited full-fidelity training settings (Alexander, Brunye, Sidman, & Weil, 2005). Other research discussed in Stewart, Johnson, and Howse (2007) suggests that less-than-full-fidelity training devices might even be beneficial for novice to mid-level trainees. Novice and mid-level trainees who are still making mistakes and learning through feedback may benefit from a simpler, more focused

training environment, more suitable for training primary skills. For trainees at the early- to mid-level of learning, high fidelity may provide no advantage for transfer to the target performance setting, and may actually introduce too much complexity into an already novel and stressing environment. In other words, the sheer complexity of the actual equipment setting in AMD may impede training for novice to mid-level trainees by making it more difficult to concentrate on the tasks at hand.

Table 1. Commonly used simulation terms and definitions.

Physical fidelity	The degree to which the physical simulation looks, sounds, and feels like the operational environment in terms of visual displays, controls, and audio as well as the physical models driving each of these variables.
Functional fidelity	The degree to which the simulation acts like the operational environment in reacting to the tasks executed by the trainee.
Buy-In	The degree to which a person recognizes that an event or experience is useful for training. Acceptance of the simulation as "relevant," and a willingness to use the environment to practice the behaviors targeted by the training program.

Source: Alexander, Brunye, Sidman, & Weil (2005)

1.3 Demonstration Objectives

The RTOS Operational Demonstration (OpDemo) was organized as a joint project involving the ADA School's DOTD-LD and the 5th Battalion 52nd ADA Regiment (5-52 ADA). 5-52 ADA is part of the 11th ADA Brigade. Personnel from ARL's HRED participated with DOTD-LD and 5-52 ADA in a technical advisory capacity. Technical support to the RTOS and other technical aspects of the OpDemo was provided by the simulator's developer, Science Applications International Corporation (SAIC).

DOTD-LD's objectives in the RTOS OpDemo were to:

1. Assess whether the RTOS could supplement existing training in the areas of (a) problem-solving for reaction to off-nominal engagement situations and (b) advanced Joint Air Defense Operations.

2. Assess the utility of the RTOS for unit-level crew training in air defense operations in preparation for PDB-6 New Equipment Training.

5-52 ADA's objective in the OpDemo was to train fire control crews in an environment conducive to coaching, teaching, and mentoring using RTOS consoles and multiple engagement scenarios. Their interest in the OpDemo was motivated by a desire to conduct additional unit-level crew training in preparation for PDB-6 NET.

In essence, the OpDemo was focused on evaluating the feasibility, utility, and potential effectiveness of a new approach to AMD unit training emphasizing deliberate practice and using the RTOS as a training vehicle. This is an important point and bears repeating. The OpDemo was not simply about the RTOS. It was focused on two separate but related objectives: (1) the

demonstration and evaluation of modified instructional methods for use in AMD unit training, and (2) an assessment of the potential utility of the RTOS as a device to support AMD unit training.

2. Method

2.1 Participants

Forty-two Soldiers from 5-52 ADA participated in the OpDemo during the period 16-27 April 2007. Time in service for the participants ranged from 18.5 years to one year, with a median length of service of two years. In terms of time in their current job position, participant responses ranged from a high of seven years to a low zero (right out of Advanced Individual Training [AIT]). The median time in their current job position was 11.5 months.

Personnel from 5-52's Alpha (A), Bravo (B), Charlie (C), and Delta (D) batteries formed the fire unit crews used in the OpDemo—Engagement Control Station (ECS) Tactical Control Officers (TCOs) and Tactical Control Assistants (TCAs). Personnel from 5-52's Headquarters and Headquarters Battery (HHB) formed the Information and Coordination Central (ICC) crews—Tactical Director (TD) and Tactical Director Assistant (TDA). Instructor personnel used in the OpDemo were from 5-52's EMMO (Electronic Missile Maintenance Officer) team and the ADA School's DOTD-LD. In Patriot units, battalion EMMO personnel provide training and evaluation support to component batteries.

2.2 RTOS Layout

The RTOS stations used in the OpDemo were set up as a suite of eight consoles representing three Patriot fire unit (FU) ECS stations and one ICC. An additional workstation representing an external Patriot battalion was used as the Air Defense Artillery Fire Control Officer (ADAFCO) display. Additionally, a simulation and support workstation area was set up to allow the instructors to both create and distribute scenarios. Figure 1 proves a graphic depiction of the RTOS layout used in the Demonstration. The site for the OpDemo was 5-52 ADA's Tactical Fire Direction Facility located at the Tobin Wells range area on Ft. Bliss.

2.3 Air Battle Operations Tasks

Twenty-three AMD air battle operations tasks were chosen for evaluation during the OpDemo. All of these are critical Patriot operator tasks for Military Occupational Specialties (MOSs) 14E (enlisted) and 14E/140E (officer/warrant officer). In addition, four high-priority operator activities associated with specific scenarios used during the OpDemo but not formally defined as tasks were added to the task list. The 27 tasks included in the OpDemo (23 "standard" plus four special) are listed in tables 2a and 2b. In tables 2a and 2b, tasks are categorized by job position:

TCA/TDA or TCO/TD. Tasks 24-27 are the extra activities included in the OpDemo. These tasks pertain to ARM classification procedures and FEZ-JEZ-MEZ operations. (Note: FEZ refers to a Fighter Engagement Zone; JEZ refers to a Joint Engagement Zone; and MEZ refers to a Missile Engagement Zone.) ARM classification procedures were selected for inclusion in the OpDemo because they represent an off-nominal performance situation that contributed to the Tornado fratricide during the combat operations phase of OIF (see Hawley & Mares, 2006). FEZ-JEZ-MEZ procedures are an important aspect of advanced Joint Air Defense Operations. The FEZ-JEZ-MEZ exercise permitted the trainees to participate in the complete kill chain for Joint Air Defense Operations from the ADAFCO located at the Air Force Controlling Authority down through the Patriot ICC to the ECS. Other unit-level training capabilities such as the embedded trainers in Patriot tactical shelters or the PCOFT at the ADA School do not currently support training on joint kill chain operations.

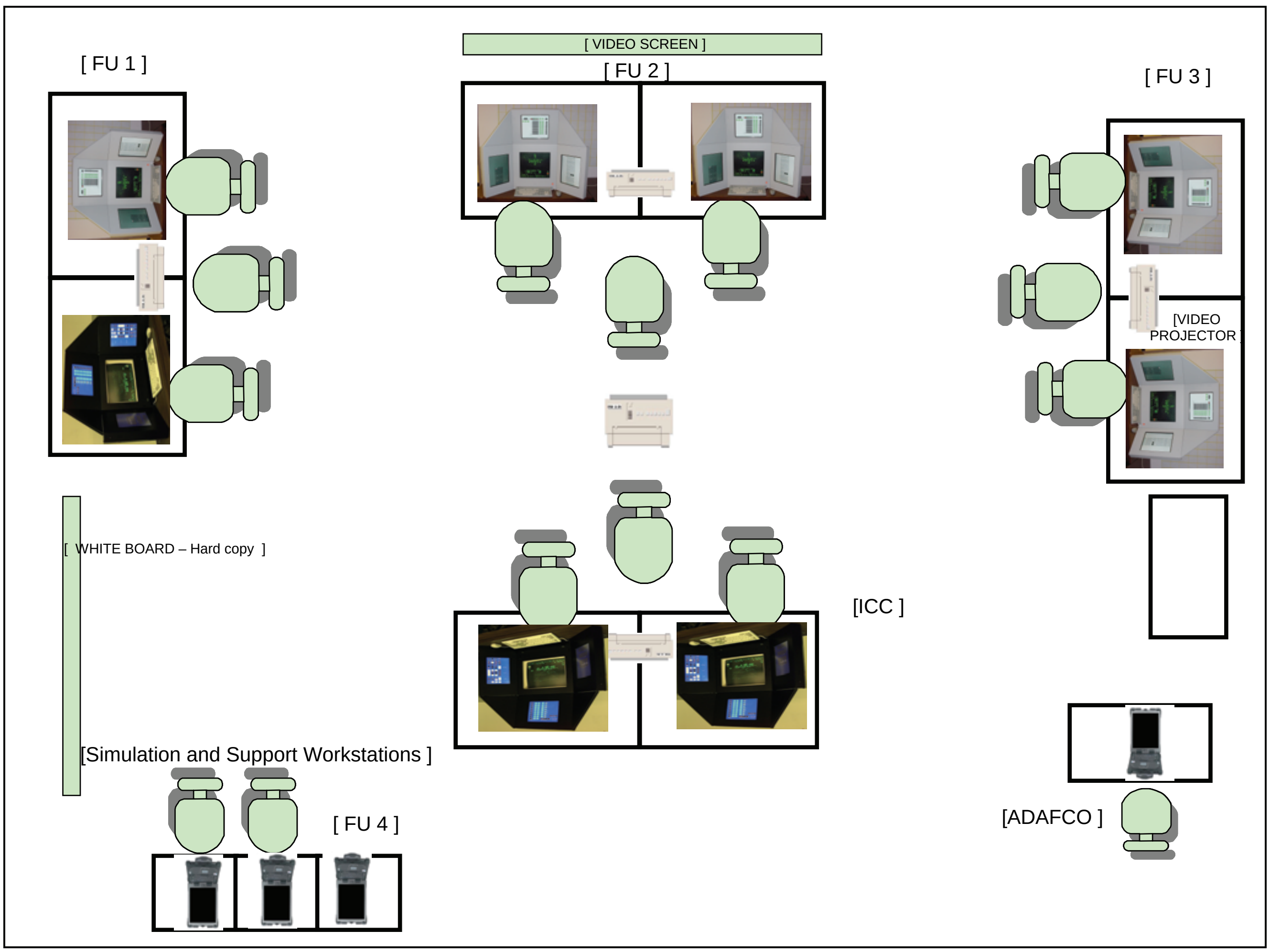

Figure 1. Reconfigurable Tactical Operations Simulator (RTOS) layout for the operational demonstration.

2.4 Training Method and Instructional Approach

Beyond the potential use of the RTOS in a unit setting, the OpDemo was intended to illustrate several modified approaches to AMD air battle operations training advocated in Hawley and Mares (2007). The first of these involved using the simulator in an open instructional environment conducive to coaching and mentoring. As trainees went through the various RAL (Reticule Aim Level—a proxy for scenario difficulty) scenarios used in the OpDemo, instructor cadre were immediately available to answer questions and provide corrective guidance. Each scenario was followed by a scenario-specific after action review (AAR) during which the trainees' performance was critiqued. It was also possible to stop the scenario at any point to review an important concept or critique and correct participant performance to that point. The stop-action feature was used several times during the OpDemo.

Several segments of the OpDemo also were used explicitly to illustrate and explore the benefits of a deliberate practice approach to training selected air battle operations tasks. As noted previously, deliberate practice denotes a hands-on instructional regimen focused on specific instructional objectives accompanied by immediate and expert feedback (Ericsson & Charness, 1994). The deliberate practice portion of the OpDemo was implemented using what might be termed a "chunk and simulate" format. Trainees were first provided with a brief (15-20 minute) slide presentation addressing the specific instructional objective at hand (the "chunk" portion). This was followed by a relatively short, simulation-based practical exercise (30 minutes) focusing on the concepts covered in the presentation. Trainees were thus immediately allowed to practice the concepts covered in the up-front presentation. The simulation portion of the exercise was followed by a focused AAR that reviewed the concept under consideration, critiqued the trainees' performance, and provided corrective guidance. Deliberate practice exercises were developed by DOTD-LD for ARM classification procedures and FEZ-JEZ-MEZ operations.

Table 2a. Tactical Control Assistant (TCA) and Tactical Director Assistant (TDA) tasks used in the operational demonstration.

	TCA/TDA Tasks
1	441-083-1478 Engage Targets on the Engagement Control Station (ECS)
2	441-083-1479 Evaluate Preengagement Data at the Engagement Control Station
3	441-083-1480 Evaluate Preengagement Data at the Information and Coordination Central
4	441-083-1482 Initiate Target Engagement at the Information and Coordination Central
5	441-083-1486 Perform Friendly Protect at the Engagement Control Station (ECS)
6	441-083-1487 Perform Friendly Protect on the Information and Coordination Central (ICC)
7	441-084-1407 Perform Engagement Control Station (ECS) Initialization

Table 2b. Tactical Control Officer (TCO) and Tactical Director (TD) tasks used in the operational demonstration.

	TCO/TD Tasks
8	441-EW1-1084 Perform Engagement Control Station (ECS) Initialization
9	441-EW1-1085 Perform Engagement Control Station (ECS) Reinitialization
10	441-EW1-1087 Direct Firing Battery System Reorientation
11	441-EW1-1088 Perform Tactical Ballistic Missile (TBM) Engagement Operations
12	441-EW1-1089 Perform Air Defense Mission in all Modes of Control for Engagement Control Station (ECS)
13	441-EW1-1090 Identify Targets at Engagement Control Station (ECS)
14	441-EW1-1091 Supervise Engagement of Targets
15	441-EW1-1093 Implement Firing Doctrine Changes
16	441-EW1-1094 Define Engagement Control Station (ECS) Tabular Displays
17	441-EW1-1095 Implement Air Breathing Threat (ABT) and Tactical Ballistic Missile (TBM) Search using Expanded Search Sectors
18	441-EW1-1099 Supervise the Process of Airspace Control Orders (ACO)
19	441-EW1-1113 Supervise Engagement Operations
20	441-EW1-1121 Analyze the Process of Evaluation, Decision, and Weapons Assignment (EDWA)
21	441-EW1-1122 Perform Friendly Protection
22	441-EW1-1123 Perform Duties and Responsibilities as the Tactical Control Officer (TCO) and Tactical Control Assistant (TCA)
23	441-EW1-1124 Perform Air Breathing Threat (ABT) and Tactical Ballistic Missile (TBM) Search Using Expanded Search Sectors
24	Identify Mis-Classified Tracks that are displayed as ARM, TBM, or ABT symbology
25	Identify when crew duties and responsibility should be modified
26	Use of a banded FEZ,JEZ, MEZ TTPs
27	Performing De-Lousing TTPs

2.5 Procedure

An overview of the structure of the OpDemo is provided in table 3. Each of 5-52 ADA's batteries (A, B, C, and D) received a full day of training each week, for a total of two days. The Fridays of each week were shared by the batteries and were focused on battalion-specified training activities. Tables 4 and 5 provide a break-out of OpDemo activities for each day. Day 1 refers to each battery's training day during the first week; Day 2 refers to that battery's training day during the second week. Table 5 shows the planned break-out of activities for the Fridays shared by the batteries, denoted as Day 3.

Day 1 began with a presentation that provided an overview of the RTOS and discussed the intent of the OpDemo. Progressive RAL scenarios then commenced. Each scenario was followed by a Hotwash during which each of the fire unit crews, the ICC crew, the EMMO team, and anyone else participating in the exercise (e.g., the simulated ADAFCO) was permitted to express their opinions both pro and con on what had transpired. The DOTD-developed FEZ-JEZ-MEZ exercise took place during the afternoon of Day 1.

Day 2 opened with a written pretest addressing the knowledge component of the ARM Classification exercise. The pretest was followed by the ARM Classification chunk and simulate training module. Following the training module, the ARM Classification knowledge test was

administered again as a posttest. The ARM Classification knowledge test used in the OpDemo is shown in appendix B. At the end of Day 2, demonstration participants were asked to complete two surveys. The first survey asked them to evaluate the RTOS in terms of how well it supported the 27 air battle operations tasks included in the OpDemo. Participants were asked to provide one evaluation for each task, with three possible levels of evaluation: *Does Not Support* (N/S), *Partially Supports* (P/S), or *Fully Supports* (F/S). The first survey addresses what Bell and Waag (1998) and Johnson and Stewart (2005) refer to as the simulator's utility for training the tasks under consideration. The Utility survey is shown in appendix C.

The second survey administered at the end of Day 2 addressed the issue of trainee Buy-In (reference table 1); it also permitted the participants to provide open-ended, written comments on the OpDemo, the instructional procedures employed, or the RTOS as a training device, along with suggestions for improvements in any of those categories. This survey, denoted the RTOS Demo Questionnaire, is shown in appendix D.

Although the OpDemo began with the schedule of activities outlined in tables 4 and 5, deviations from the plan occurred. For example, some of the battery crews were more advanced than others and progressed more rapidly, thus requiring the use of more difficult RAL scenarios near the end of their scheduled time. Similarly, some of the battery crews were not as far along in their training sequence as had been assumed, and thus required more practice on less complex scenarios. The schedule was also adjusted to accommodate visits to the OpDemo site by VIPs. These schedule adjustments permitted the VIPs to view and comment on salient aspects of the OpDemo such as the ARM Classification and FEZ-JEZ-MEZ training modules. VIPs visiting the OpDemo site included the Ft. Bliss Commanding General and members of his staff, the Commander of the 32nd Army AMD Command (AAMDC), various AMD brigade and battalion commanders and their staffs, and representatives from the AMD Lower Tier Project Office. Patriot is classified as an AMD Lower Tier system.

Table 3. Operational demonstration training support timeline: 16 to 27 April 2007.

April				
MON	**TUE**	**WED**	**THUR**	**FRI**
16 ALPHA (A)	17 BRAVO (B)	18 CHARLIE (C)	19 DELTA (D)	20 BRAVO (Two Crews) CHARLIE (One Crew)
23 ALPHA	24 BRAVO	25 CHARLIE	26 DELTA	27 ALPHA (One Crew) DELTA (Two Crews)

Table 4. Daily training schedule for days 1 and 2.

DAY 1	DAY 2
0900-0930 RTOS Overview	0900-0930 Written Test
0930-0950 Crew in brief	0930-0950 ARM Presentation
0950-1000 Break	0950-1000 Break
1000-1045 1st Air Battle (RAL 5)	1000-1045 ARM Scenario with discussion
1045-1050 Break	1045-1100 Written Test
1050-1105 Hotwash	1100-1115 Break
1105-1150 2nd Air Battle (RAL 9)	1115-1200 Test review and Hot Wash
1150-1200 Hotwash	1200-1300 Lunch
1200-1300 Lunch	1300-1315 Crew in brief
1300-1330 Crew in brief (DOTD JEZ)	1315-1350 5th Air Battle
1330-1400 3rd Air Battle (DOTD JEZ)	1350-1400 Break
1400-1415 Break	1400-1430 Hotwash
1415-1450 Hotwash with discussion	1430-1440 Break
1450-1500 Break	1440-1500 Crew in brief
1500-1550 4th Air Battle (RAL 11)	1500-1550 6th Air Battle
1550-1600 Break	1550-1600 Break
1600-1630 AAR (for both scenario and day)	1600-1630 AAR/ Written test (for both scenario and day)

Table 5. Daily training schedule for day 3.

DAY 3
0900-0915 Crew in brief
0915-0950 8th Air Battle (BN Focus)
0950-1000 Break
1000-1030 Hotwash
1030-1115 9th Air Battle (BN Focus)
1115-1130 Break
1130-1200 Hotwash
1200-1300 Lunch
1300-1315 Crew in brief
1315-1350 10th Air Battle (BN Focus)
1350-1400 Break
1400-1430 Hotwash
1440-1600 Unit Focused Events
1600-1630 AAR/ RTOS Surveys

3. Results

3.1 Utility Evaluation

Data from the Utility assessment of air battle operations tasks are presented in tables 6a and 6b. Table 6a presents results for TCA and TDA tasks, while table 6b presents results for TCO and TD tasks. Responses to the Utility survey were first screened to ensure that respondents held the proper MOS. This initial screening resulted in five participants being eliminated from the analysis (all 25Fs or 14Js). The remaining surveys were then screened again to ensure that respondents had the proper background (job assignment, time in the job position, etc.) to provide a valid assessment of the RTOS' utility for training the task in question. Screenings were done by Patriot subject matter experts (SMEs) from DOTD-LD. The secondary screening resulted in the numbers given in the table columns labeled *Total*.

The utility assessment results shown in tables 6a and 6b indicate that a large majority of the participants judged the RTOS to have utility for training the air defense operations tasks used in the OpDemo. In most cases, a large majority of the survey responses were for fully supports (F/S) or partially supports (P/S). The only exceptions to this general observation are for Tasks 7, 8 and 9. These tasks all concern System Initialization and Reinitialization. At present, the RTOS does not support these tasks fully.

After reviewing results from the Utility survey, Patriot SMEs from DOTD-LD cautioned that because of their lack of experience some participants might not have fully understood the complete scope of the tasks involved or what the survey questions implied. Consequently, while the Utility results support a general conclusion that the RTOS has value for training air defense operations tasks, further inquiry is necessary before making definitive conclusions regarding the device's specific strengths or weaknesses. Clearly, however, most of the participants came away from the OpDemo with a favorable impression of the RTOS and its potential use as a unit-level training device.

Table 6a. Utility evaluation ratings for Tactical Control Assistant (TCA) and Tactical Director Assistant (TDA) tasks.

	TCA/TDA Tasks	Total	N/S	P/S	F/S
1	Engage Targets on the Engagement Control Station (ECS)	20	0	5	15
2	Evaluate Preengagement Data at the Engagement Control Station	21	1	4	16
3	Evaluate Preengagement Data at the Information and Coordination Central	12	0	1	11
4	Initiate Target Engagement at the Information and Coordination Central	12	0	1	11
5	Perform Friendly Protect at the Engagement Control Station (ECS)	22	1	5	16
6	Perform Friendly Protect on the Information and Coordination Central (ICC)	18	1	1	16
7	Perform Engagement Control Station (ECS) Initialization	20	3	8	9

Table 6b. Utility evaluation ratings for Tactical control Officer (TCO) and Tactical director (TD) tasks.

	TCO/TD Tasks	Total	N/S	P/S	F/S
8	Perform Engagement Control Station (ECS) Initialization	17	0	6	11
9	Perform Engagement Control Station (ECS) Reinitialization	17	0	9	8
10	Direct Firing Battery System Reorientation	19	0	6	13
11	Perform Tactical Ballistic Missile (TBM) Engagement Operations	17	0	0	17
12	Perform Air Defense Mission in all Modes of Control for Engagement Control Station (ECS)	17	2	4	11
13	Identify Targets at Engagement Control Station (ECS)	19	0	1	18
14	Supervise Engagement of Targets	19	0	1	18
15	Implement Firing Doctrine Changes	19	0	2	17
16	Define Engagement Control Station (ECS) Tabular Displays	19	0	1	18
17	Implement (ABT) and Tactical Ballistic Missile (TBM) Search using Expanded Search Sectors	19	0	2	17
18	Supervise the Process of Airspace Control Orders (ACO)	19	3	2	14
19	Supervise Engagement Operations	19	0	3	16
20	Analyze the Process of Evaluation, Decision, and Weapons Assignment (EDWA)	19	0	4	15
21	Perform Friendly Protection	19	0	3	16
22	Perform Duties and Responsibilities as the Tactical Control Officer (TCO)	18	0	1	17
23	Perform Air Breathing Threat (ABT) and Tactical Ballistic Missile (TBM) Search Using Expanded Search Sectors	19	0	1	18
24	Identify Mis-Classified Tracks that are displayed as ARM, TBM, or ABT symbology	19	0	1	18
25	Identify when crew duties and responsibility should be modified	19	0	2	17
26	Use of a banded FEZ,JEZ, MEZ TTPs	19	0	2	17
27	Performing De-Lousing TTPs	19	0	2	17

3.2 Pre- Post-Test Results

Bell and Waag (1998) list three categories of approach for evaluating the training effectiveness of simulators. Utility evaluations are the easiest and quickest to obtain, and are reported in the previous subsection. The second category of evaluation is in-simulator learning. Trainees practice tasks in the simulator and thereby show learning through an improvement in performance. Typically, the method is one of pre-test, practice, and then post-test. This general approach was used to assess the training effectiveness of the RTOS coupled with the chunk-and-simulate instructional approach for the ARM Classification module. Bell and Waag's third category, transfer of training to the job setting, was beyond the scope of the OpDemo. The project staff will, however, continue to track the transfer of training issue during subsequent training and performance certification activities involving 5-52 ADA.

Pre- and post-training results for the ARM Classification module are summarized in table 7. The mean score on the pre-training knowledge test was 18.78. After the chunk-and-simulate session, the mean score was 67.92. The mean improvement across participants was 49.14 points. Difference scores for each of the 37 MOS-qualified participants completing both the pre- and post-tests were evaluated using a paired-sample t-test. The t-test resulted in an observed t statistic of 12.91 with 36 degrees of freedom ($p < .001$). The differences in knowledge test performance pre- and post-training module are large and statistically significant.

Table 7. Pre- and post-training results for the ARM classification training module.

		Preliminary Test	**Post-Training Test**	**Change Score**
N=37				
Mean		18.78	67.92	49.14
SD		16.73	23.95	23.15

3.3 Buy-In Results

Recall from table 1 that Buy-In is defined as "the degree to which a person recognizes that an event or experience is useful for training: Acceptance of the simulation as 'relevant,' and a willingness to use the environment to practice the behaviors targeted by the training program." Buy-In is an important consideration with respect to the selection of any simulator. Research has shown (e.g., Salas, Bowers, and Rhodenizer, 1998) that trainee buy-in, or acceptance of a simulator or instructional setting as a legitimate training experience, is an important determinant of whether they will willingly use it and take the training experience seriously.

Buy-In was assessed using the five statements listed as follows:

1. The RTOS unit training environment is more conducive to coaching, teaching, and mentoring than the current method used to train.
2. I learned new advanced Joint Air Defense Operations techniques.
3. I learned techniques to evaluate and react to off-nominal situations (misclassifications, anomalies, etc.).
4. All things considered, this demonstration was a worthwhile training event.
5. I think the RTOS will be a useful tool for unit training.

Participants were asked to agree or disagree with each statement.

Response totals for each statement are given in table 8. For each statement, a large majority of participants indicated agreement with the statement. For statements 4 and 5, participant agreement was unanimous (100% Agree): Participants uniformly agreed that the Demonstration was a worthwhile training event and that the RTOS would be a useful tool for unit training. The lowest percentage of favorable response was for statement 1. Here, only 37 of the 42 (88.1%) participants expressed agreement that the RTOS as used in the OpDemo was more conducive to coaching, teaching, and mentoring than the current method used to train.

Table 8. Buy-In survey results.

Statement	Agree	Pct (%)	Disagree	Pct (%)	Total
1	37	88.10%	5	11.90%	42
2	40	95.24%	2	4.74%	42
3	40	95.24%	2	4.76%	42
4	42	100.00%	0	0.00%	42
5	42	100.00%	0	0.00%	42

3.4 Open-Ended Comments

The RTOS Demo Questionnaire also permitted participants to provide open-ended comments concerning their experiences during the OpDemo. Two open-ended questions were posed to OpDemo participants:

1. Comments? (Environment, Training, RTOS Issues, General Impressions)
2. What does the RTOS need to do that it does not currently do?

A list of all participant responses to item 1 is provided in appendix E. Participant responses to the second question concerning RTOS limitations generally tended to reflect the same issues and opinions obtained during the post-scenario Hotwash sessions. These results are addressed in the next subsection on Hotwash comments. For each comment in appendix E, the respondent's rank and current job position or MOS are provided as an identifying header.

A review of participant responses in appendix E indicated an overall favorable opinion of the OpDemo, the RTOS, and the way it was used—the instructional approach focusing on deliberate practice. Participant comments were consistent with the Utility and Buy-In results presented previously. Many participants picked up on and commented favorably on the fact that the instructional experience provided during the OpDemo was different from standard training practices in AMD units. They liked the way training was done during the OpDemo. For the several respondents remarking that they liked the RTOS better than the PCOFT, follow-on, one-on-one interviews indicated that their unfavorable comments regarding the PCOFT resulted from the manner in which the PCOFT is currently used rather than any negative impressions of the simulator itself.

3.5 Hotwash Comments

At the conclusion of each scenario session a Hotwash was conducted. In present usage, the term Hotwash refers to a debrief session during which each group of participants was permitted to comment on the conduct of the exercise, their experiences with the RTOS, or any other topic they wished to bring up. A total of 30 Hotwash sessions were conducted over the two weeks of the OpDemo. For purposes of analysis, positive comments and criticisms from all 30 Hotwash sessions were aggregated by common themes. A total of three positive and four negative themes ran through participant Hotwash comments.

The three positive Hotwash themes that emerged from participant comments were:

1. Participants liked the overall training approach characterized by an open instructional environment with ready access to instructor cadre for feedback and corrective guidance.
2. Participants liked the chunk-and-simulate instructional approach used for the JEZ-FEZ-MEZ and ARM Classification training modules.
3. Participants viewed the OpDemo as an enjoyable, motivating instructional experience.

With respect to the third Hotwash theme, one relatively experienced participant remarked that an instructional setting like that used in the OpDemo might make personnel "now avoiding the vans want to be in the vans." The implication here is that training inside the tactical shelters (the vans) using the embedded trainers is a somewhat unpleasant experience, one that many AMD personnel avoid whenever possible.

The four negative Hotwash themes reported by OpDemo participants were:

1. Frequent and recurring RTOS "glitches," or technical problems experienced during the Demonstration.
2. RTOS physical fidelity and ergonomic issues—differences between the RTOS and Patriot tactical equipment or near-full-physical-fidelity trainers such as the PCOFT.

3. RTOS functional fidelity issues—RTOS functional limitations or differences between the way the system performs actions and the way these same functions currently are performed using the RTOS.

4. The way ECS-ICC communications were handled during the Demonstration—the lack of headsets for ECS and ICC crews resulting in a somewhat noisy and chaotic training setting.

Many of the RTOS features underlying these negative themes are already being addressed. For example, the RTOS developer and support contractor, SAIC, has already responded to a number of the participants' comments, and others are under investigation for correction. A summary of RTOS modifications currently performed, underway, or under consideration as a result of the OpDemo is given in table 9. In all fairness, it should be noted that the support contractor had only a two-week preparatory period to install and integrate the RTOS workstations, develop and test scenarios, and refine the training environment.

Table 9. RTOS issues and modifications resulting from participant hotwash comments.

- First time used as a trainer and fully integrated with 8 consoles
- Simulation running prototype software (TACI/K7/OB)
- 70 hours of training, 13 simulation aborts (3 hrs downtime) = 96% available
    - Fire Platoon TAB 54 entries - 3 instances (software fixed)
    - Fire Platoon TAB 01 entries – 5 instances (software fixed)
    - Battalion TAB 55 entries - 2 instances (software fixed)
    - Battalion TAB 14 entries - 2 instances (software fixed, being tested)
    - One console loss of power during simulation (moved power strip)
- Software Problems – 18 software problems were identified, 10 were corrected, 8 under investigation
- Simulation Differences from Tactical System – 17 differences between the tactical system and the simulation were identified by the operators. 11 were corrected and 6 under investigation
- Requested Simulation Enhancements Identified by Operators and Trainers
    - Remote Tracks at ECS
    - Ability to perform Battalion Initialization and Command Plan
    - Ability to perform Mapping
    - Ability to change TABS 70, 71, and 72 during tactical operations
    - Ability to perform clutter map update
    - Emulation of tactical communications networks between FPs, ICC, and ADAFCO
    - FU-FU capabilities

4. Discussion

As emphasized throughout the report, the RTOS OpDemo was an exercise intended to illustrate and evaluate the feasibility and acceptability of a new training approach for possible use in AMD units using the RTOS as a training vehicle. The new training approach emphasized deliberate

practice within an open instructional environment conducive to teaching, coaching, and mentoring.

It should be noted that the Demonstration was not a training experiment. No novice fire unit crews were trained to criterion using the RTOS coupled with the new instruction instructional strategy and then compared to a comparable control group. It was more similar to a demonstration and case study than a controlled experiment. Consequently, any generalizations of results from the OpDemo are limited and must be made cautiously. However, despite these limitations and cautions, selected conclusions can be stated.

First, the OpDemo results indicated that the RTOS has potential utility to support AMD unit training for air battle operations. Results from the Utility assessment strongly support this conclusion. In addition, results from the Buy-In survey indicate that participants viewed RTOS-based training as a legitimate training experience and were willing to accept it as a training tool. Both of these conclusions are further supported by participant responses to the Open-Ended survey questions and Hotwash remarks.

With targeted modifications, the results suggest that the RTOS has sufficient physical and functional fidelity to be useful in the early to mid-ranges of the AMD training sequence. Potential categories of enhancements to the RTOS include:

1. Ergonomic enhancements to increase physical fidelity.
2. Functional modifications and add-ons.
3. Instructional support features.

Potential ergonomic and functional modifications were addressed in the previous section. Instructional support features are simulator modifications added to enhance the instructional process the device is intended to support. These include features such as stop-action, rewind, fast-forward, real-time replay from a fast-forward or rewind point, performance evaluation assists, and the like. It is also essential that the RTOS support the latest version of Patriot tactical software and that software upgrades be accomplished in a timely manner.

In spite of the favorable review given the RTOS, AMD decision makers must bear in mind that simulators by themselves do not train. They are tools used by good instructors operating within a well-designed instructional strategy to achieve training objectives. Research on training effectiveness has consistently shown that how a simulator is used is more important than specific simulator features or simulation technologies (Salas, Bowers, & Rhodenizer, 1998). Moreover, a large base of training research indicates that more fidelity is not always better (Alexander, Brunye, Sidman, & Weil, 2005). These latter authors note that "a compromise must be made between physical fidelity, related costs, and training effectiveness, such that an adequate match can be made between training and real environmental elements and the logical structure of [the] tasks [to be trained]" (p. 7). They go on to note that the relationships among simulation fidelity,

user acceptance, and training effectiveness are not well understood. Each case must be explored heuristically based on its own merits, requirements, and knowledge base. The term heuristically means exploration using experimental, trial-and-error methods. The OpDemo was an example of a heuristic approach to problem exploration.

In spite of the fidelity conundrum, the literature on simulators and simulations is clear on one point (Salas, Bowers, & Rhodenizer): Developers must avoid the blind pursuit of fidelity for its own sake. These authors (p. 200) note that realism (i.e., physical and functional fidelity) as a sole simulator design criterion "has led us to the point where in the quest for more realistic simulation, we have lost sight of the true goal—a more effective training device in terms of both training outcomes and cost. The two are not the same."

Second, the training strategy focusing on deliberate practice and characterized by an open instruction setting conducive to teaching, coaching, and mentoring was well received by OpDemo participants. Buy-In results, Open-Ended survey results, and Hotwash comments all support this conclusion. Participants liked the instructional approach used in the OpDemo and thought it should be further applied in a unit setting. In addition, pre- and post-test results from the ARM Classification training module indicate that the approach was effective. Pre- versus post-instruction test results showed significant positive improvement. Similar anecdotal results were observed for the JEZ-MEZ-FEZ instructional module.

Third, there was remarkable consistency across the categories of data obtained over the course of the OpDemo. Utility results, Buy-In Survey results, Open-Ended comments, and Hotwash remarks all paint a consistent picture of user acceptance and potential training effectiveness. Such consistency suggests that in spite of the limitations on interpretation and generalization noted previously, the ADA School has a "green light" to pursue further applications of the RTOS (or an RTOS-like device) and the modified instructional strategies used during the OpDemo. In this respect, the RTOS OpDemo must be view as a success. Moreover, the training set-up used during the OpDemo (RTOS plus modified instructional approach) represents a partial prototype for a solution to the training deficiencies that contributed to the OIF fratricides and that showed up again during the PDB-6 Limited User Test.

These latter two conclusions have considerable support within the training effectiveness literature. For example, Salas, Bowers, and Rhodenizer (1998) argue that the training community must emphasize training systems that use technology to promote learning. As mentioned previously, this requires a shift from designing simulation solely for realism—and hoping that learning occurs—to the design of *human-centered* training systems that support the acquisition of complex skills. These authors go on to assert that achieving this goal will require a paradigm shift from a focus on simulation to a broader consideration of the entire training system, of which the simulator is but one component. In essence, this comment summarizes the approach used in the OpDemo and that met with an overwhelmingly favorable response from participants.

In spite of the success observed during the OpDemo, it would be a mistake to deploy the RTOS or any such device to AMD units without an extensive training support package and the requisite command acceptance, support, and emphasis. Without these dual elements of support, the present initiative to improve AMD unit training and enhance unit performance will fail. For the RTOS or any similar simulator, essential training support requirements *must* include:

1. An overall AMD training strategy into which such a device fits.
2. Enhanced instructional methods (e.g., vignettes supporting progressive instructional objectives and deliberate practice versus simple free-play in a scenario-based environment).
3. Pedagogical modifications (e.g., changes in the way instructors conduct unit training).
4. Courseware support (scenario templates, training and evaluation guides, etc.).
5. Technical support to the simulator itself.

All of these support elements are critical to the successful application an instructional regimen emphasizing deliberate practice within an open learning environment, regardless of the simulator selected for use.

Success in an AMD training reform effort also may require a re-look at the issue of what must be trained. Current job and task analysis products for Patriot and other AMD systems may not support the instructional approach used during the OpDemo without extensive modifications and clarifications. For example, the JEZ-MEZ-FEZ and ARM Classification modules used during the OpDemo are not included in official Critical Task Lists for Patriot MOSs, yet these modules involve skills that are essential to successful job performance in the contemporary Patriot operational environment.

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Appendix A. RTOS Patriot PDB-5 Tactical System Representation

The Reconfigurable Tactical Operations Simulator (RTOS) system began its development in 1977 under contract with the U.S. Army Missile Command (MICOM). In 1981, the responsibility of the system was transferred to the U.S. Army Air Defense Artillery School (USAADASCH) at Ft. Bliss, Texas. The RTOS has undergone extensive enhancements to replicate the functions of the deployed Patriot Tactical System and Support simulation models of other Air Defense systems. The U.S. Army renamed the Patriot Tactical Operations Simulator (PTOS)-to-RTOS in 1989 because of the additional air defense simulations added, the use of reconfigurable consoles, and the incorporation of Distributed Interactive Simulation (DIS) into the RTOS architecture. These capabilities enable the RTOS to be used as a multiple-system air defense simulator with growth capabilities to incorporate additional weapon or command-and-control systems and participate in exercises and training events.

RTOS Patriot simulation provides a high fidelity representation of the PATRIOT software in key functional areas that support studies, exercises and training. Since its initial development, the RTOS Patriot model was based on Data Processing System Requirements (DPSR) documents of the tactical Patriot system and provides algorithm representation of the functional areas supporting its role as an analysis tool for the U.S. Army's Directorate of Combat Developments (DCD). The RTOS Patriot simulator uses two levels of modeling: algorithmic and probabilistic. During the early development of the Patriot Missile System, the RTOS was used by USAADASCH to implement, verify, and validate the proposed Patriot tactical software. Impacts on established tactics and doctrine were identified and resolved before the tactical system software became operational. A major engineering revision to the tactical software could be identified and tested before implementation of the system software, avoiding costly and time-consuming modifications to the tactical Patriot software before fielding.

The RTOS Patriot is capable of representing a full battalion configuration of up to six Fire Platoons made up of single or dual console representations of ICC and ECSs. The RTOS ECS representation can either be interactive with Reconfigurable consoles or they can be represented in batch (non-interactive) with internal operator representations.

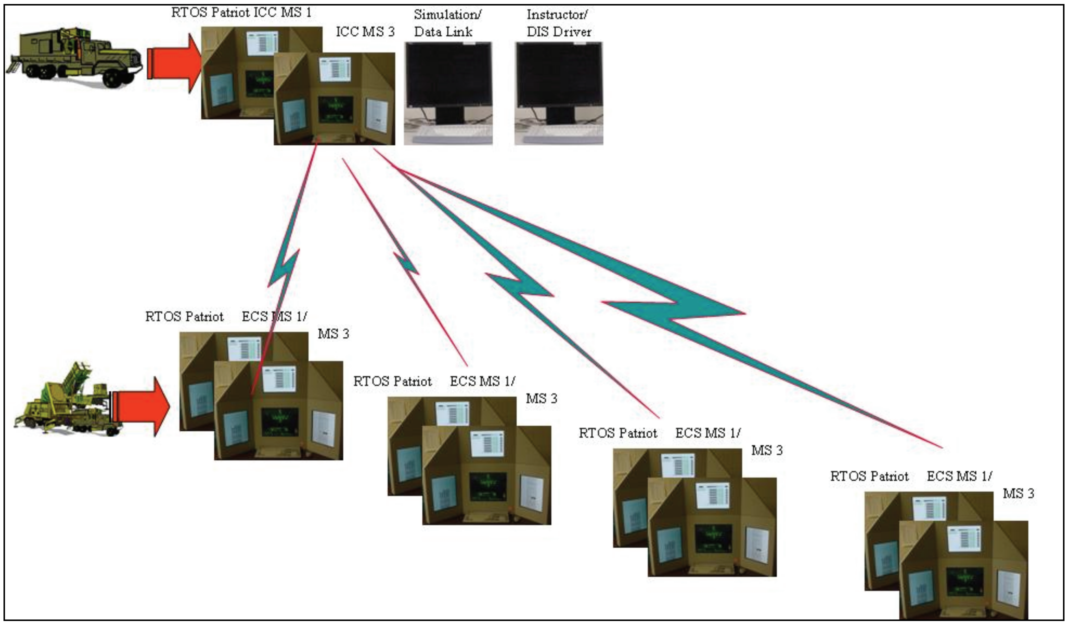

Figure A-1. RTOS Patriot system battalion representation.

A-1. RTOS Users

The RTOS plays an important role in the U.S. Army's participation in multilevel air defense demonstrations and exercises. From the earliest days of the PPO, through the deployment of the first operational Patriot software revision and refinement to the present configuration, the RTOS has been an important Soldier-in-the-loop air defense tool supporting studies and exercises. Although the proponent and owner of the RTOS system is USAADASCH, there are other users that support the RTOS. The German Air Force (GAF) used the RTOS system for more than 17 years. The German Patriot Project Office (GEPO), located at Ft. Bliss, Texas, uses the system in conjunction with the Army to produce studies and recommendations for future Patriot system changes as part of bi-lateral studies. The RTOS Patriot system was procured by the Japan Defense Agency (JDA) with five RTOS consoles in 1996 and installed at Iruma Air Base, Japan and includes both PDB-3 and PDB-4 representations.

Figure A-2. The RTOS system.

In addition to the U.S. Army, the German and Japanese Air Force, other users and supporters of the RTOS include the Missile Defense Agency (MDA), Joint Tactical Air and Missile Defense Office (JTAMDO), Space and Missile Defense Command (SMDC), and AMRDEC-Software Engineering Directorate with permanent RTOS systems located in their facilities (Ft. Bliss Warfighting Center, AMRDEC-SED-Redstone, JNIC-Colorado Springs, JASDF- Japan, SMDC Battle Lab - Redstone, and Virtual Warfare Center-St. Louis).

A-2. Model Configuration

RTOS supports both Standalone and Distributed simulations. Stand-alone simulations are supported with the RTOS support programs that use a scenario generated by the internal Scenario Generation Program supporting threat development of Air Breathing Threats (ABT), Tactical Ballistic Missiles (TBM), and Cruise Missiles. Distributed simulations are supported by the RTOS DIS capability which allows the RTOS to be driven by other models and interact with other non-RTOS models either in the RTOS facility or externally over data/phone lines. This capability allows other models to provide higher fidelity threat interjection. The characteristics of RTOS are the following:

- Supports real-time execution on large size scenarios
- Supported by user-definable parameters and event scheduling
- Supports customization via its modular design to allow new air defense models to be incorporated into the existing models.

RTOS is supported by Interactive Support Programs that support the users' ability to use RTOS as a standalone trainer or as a exercise support tool. Support programs include: Scenario Generation Program, Namelist Program, Event Calendar File Program, Data Reduction Program and the capability to supports individual console replay. The RTOS system allows the Integration of Multiple RTOS systems locally through Ethernet connections. This capability allows different RTOS models (for example Patriot and SLAMRAAM) to execute together using the same scenario. Using the DIS standard and defined protocol data units, RTOS models can be linked together with other models in other locations

A-3. Hardware

The RTOS system is composed of off-the-self hardware components. The simulation and console computer systems are supported by multiple processor platforms to include Silicon Graphics, SUN and PC. The reconfigurable console system provides a display for the air defense systems during the simulation and is composed of two 30 inch high resolution LCD touch screens with replica keyboards and joy-stick. The reconfigurable console is modular and easily transported.

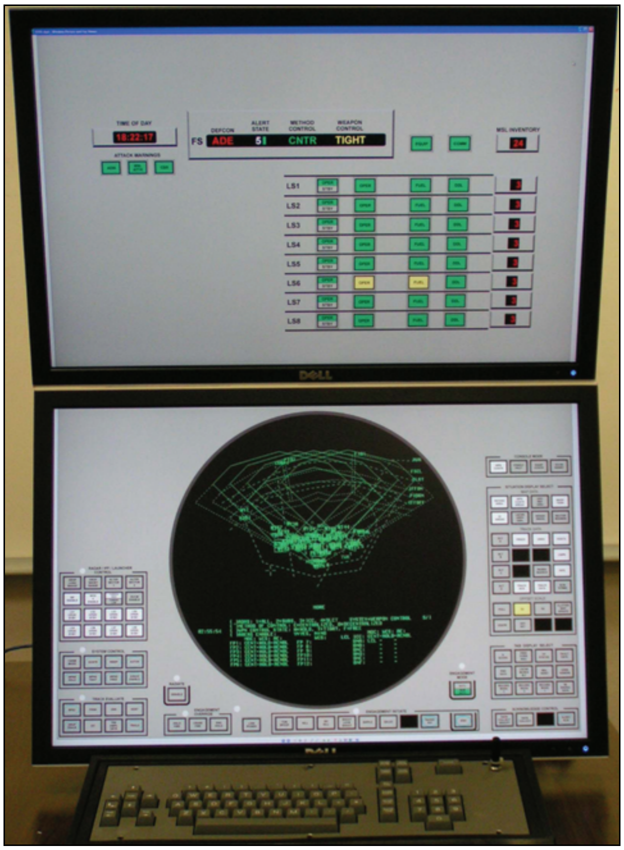

Figure A-3. Latest RTOS Reconfigurable Console Display.

A-4. Software Architecture

The RTOS is a highly flexible and realistic simulator of multiple air defense weapon systems. Its design concept was driven by the goal to develop an analysis tool with an open system architecture that can be adapted to growing needs without costly redesign. The very extensive software strictly follows actual system specifications, has been coded in a high-order language, and consists of over 150,000 lines of code. A modular design structure allows for easy and low-risk modifications, extensions, and even the addition of complete new system models. This flexibility supports rapid and inexpensive responses to changes in weapons system software. It also supports the analyst's need for specific modifications to the simulation models necessary to enforce a very particular system performance within specific analyses. The majority of the model areas of the RTOS are supported by user-modifiable parameters and probabilities. These areas include the following:

- Surveillance and radar
- Missile
- Tracking
- Identification Friend of Foe (IFF)
- Time thresholds
- Identification
- Selection
- Data links
- Display.

A-5. RTOS Patriot Simulation Software

The Patriot software of the RTOS is periodically upgraded to reflect changes in the fielded Patriot system and currently maintains baselines for PDB-3, PDB-4, and PDB-5 and initial development of PDB-6. The RTOS Patriot ICC controls up to six Patriot Engagement Control Stations (ECS). The reconfigurable consoles can be configured as ICC and/or ECS.

The Fire Unit-level model in RTOS Patriot is represented by the major functions of: Surveillance/Track, Classification / Identification, Threat Assessment/Engagement Decision, Weapon Assignment/Missile Guidance, and Kill Assessment/Attacker Penetration. The Engagement Decision and Weapon Assignment (EDWA) function is an example of an algorithmic level of modeling, which models the tactical operations processing for the Patriot FUs. The EDWA function provides threat evaluation of detected targets, ID, target classification, threat assessment and engagement eligibility evaluation, engagement processing

and response to ICC messages and operator actions. Processing to accomplish these tasks during a scenario is based upon the algorithms outlined by the Patriot EDWA DPSR.

Track management at the FP is an example of a probabilistic level of modeling. It models the detection of threat groups and maintenance of the track position, velocity and selected track status information. The detection and tracking process is based on a surveillance procedure that includes a radar model of the Patriot FP radar characteristics and probability factors that can be set by the user. Masked terrain effects on the radar visibility are supported. High-fidelity software modules, which replicate established Patriot data link, Patriot Data Interface Language (PADIL), are employed to model actual data communications behavior.

The RTOS Patriot model replicates the Command and Control function of the Patriot battalion and provides target evaluation, engagement-control, and processing-command input from the operator or higher echelon (HE). Evaluation consists of target Identification (ID) and Identification Friend or Foe (IFF) processing classification, threat assessment and protection of assets, engagement eligibility, and selection of a FP to conduct the engagement. Engagement control includes pre-engagement processing of threats, computation of engagement data, and maintenance of the to-be-engaged queue (TBEQ), engagement release to subordinate units, and the monitoring and kill assessment of ongoing engagements. Command input provides processing of commands from the operator, via switch action, or from HE via data link message. These include engage, hold-fire, cease-fire, and engage-hold. Operators may release hold-fire, cease-fire, and engage-hold commands. Major portions of data communications between subordinate units and the battalion C2 element are included in the RTOS. The communications model uses PADIL and external tactical higher echelon TADIL-J data link. The TADIL-J datalink allows the RTOS Patriot ICC to directly connect with any higher echelon element. SAIC has supported over 50 simulation and training exercises with the TADIL-J data link.

Appendix B. ARM Classification Knowledge Test

Date________________

Soldier Rank and Name:_______________ ______________________

Unit:____________ Crew Position______________ Age:__________

Military Education: ____

Civilian Education____

Do you have a PC at Home?__________ Do you play video games?________

PC or Console?_______________

1. What are the three tests that the system uses to determine if a track is an ARM

    1.
    2.
    3.

2. What are some general characteristics that the system uses to determine if a track is an ARM?

3. What does the Config 3 Radar add as a requirement for the system to classify a track as an ARM?

4. What is the primary discriminant for classifying a track?

5. Target classification is NOT reassessed after a classification is ____________.

6. The default tab setting in Tab 76 page A for range is ___________.

7. The default tab setting in Tab 76, page A for minimum speed is __________.

8. If you have an AS-11 threat, your minimum speed tab setting is ___________ as per the PDB 5.5.2 Speed Values for ARM Threats white paper.

9. If you have an AS-17a threat, your minimum speed tab setting is ___________ as per the PDB 5.5.2 Speed Values for ARM Threats white paper.

10. What tab setting should you authorize to improve ARM detection performance as per the PDB 5.5.2 Improving ARM Detection Performance White Paper?

Appendix C. Utility Assessment Survey

Date________________

Soldier Rank and Name:_______________ ______________________

Unit:____________ Crew Position______________ Age:__________

Military Education: ____

Civilian Education____

Do you have a PC at Home?__________ Do you play video games?________

PC or Console?_______________ What Genre (RPG,RTS,FPS):______

	Task	N/S	P/S	F/S
	TCA/TDA Tasks			
1	441-083-1478 Engage Targets on the Engagement Control Station (ECS)			
2	441-083-1479 Evaluate Preengagement Data at the Engagement Control Station			
3	441-083-1480 Evaluate Preengagement Data at the Information and Coordination Central			
4	441-083-1482 Initiate Target Engagement at the Information and Coordination Central			
5	441-083-1486 Perform Friendly Protect at the Engagement Control Station (ECS)			
6	441-083-1487 Perform Friendly Protect on the Information and Coordination Central (ICC)			
7	441-084-1407 Perform Engagement Control Station (ECS) Initialization			
	TCO/TD Tasks			
8	441-EW1-1084 Perform Engagement Control Station (ECS) Initialization			
9	441-EW1-1085 Perform Engagement Control Station (ECS) Reinitialization			
10	441-EW1-1087 Direct Firing Battery System Reorientation			
11	441-EW1-1088 Perform Tactical Ballistic Missile (TBM) Engagement Operations			
12	441-EW1-1089 Perform Air Defense Mission in all Modes of Control for Engagement Control Station (ECS)			
13	441-EW1-1090 Identify Targets at Engagement Control Station (ECS)			
14	441-EW1-1091 Supervise Engagement of Targets			
15	441-EW1-1093 Implement Firing Doctrine Changes			
16	441-EW1-1094 Define Engagement Control Station (ECS) Tabular Displays			
17	441-EW1-1095 Implement (ABT) and Tactical Ballistic Missile (TBM) Search using Expanded Search Sectors			
18	441-EW1-1099 Supervise the Process of Airspace Control Orders (ACO)			
19	441-EW1-1113 Supervise Engagement Operations			
20	441-EW1-1121 Analyze the Process of Evaluation, Decision, and Weapons Assignment (EDWA)			

21	441-EW1-1122 Perform Friendly Protection			
22	441-EW1-1123 Perform Duties and Responsibilities as the Tactical Control Officer (TCO)			
23	441-EW1-1124 Perform Air Breathing Threat (ABT) and Tactical Ballistic Missile (TBM) Search Using Expanded Search Sectors			
24	Identify Mis-Classified Tracks that are displayed as ARM, TBM, or ABT symbology			
25	Identify when crew duties and responsibility should be modified			
26	Use of a banded FEZ,JEZ, MEZ TTPs			
27	Performing De-Lousing TTPs			

Appendix D. RTOS Demo Questionnaire

Primary MOS ______________________ Duty MOS ___________________ Rank _______

Job/Position ______________________ # Yrs Service ___________ # Yrs in Position ___

Please comment on any response of (1) Disagree to (2) Agree

Statement	Disagree (1)	Agree (2)
1. The RTOS Unit training environment is more conducive to coaching, teaching and mentoring then the current method used to train.		
2. I learned new advanced Joint Air Defense Operation techniques.		
3. I learned techniques to evaluate and react to off nominal situations (misclassifications, anomalies)		
4. All things considered, this demo was a worth while training event.		
5. I think the RTOS will be a useful tool for unit training.		

6. Comments: (Environment, Training, RTOS issues, General Impressions).

7. What does the RTOS need to do that it does not currently do?

Appendix E. Open-Ended Survey Responses

SPC/TDA: RTOS does not have the capability to surpass training on actual equipment. However, RTOS would be great tool to deployed units where system equipment is not readily available for training. RTOS would be good for use with a tactical seminar situation as a demonstration tool for specific tactical situations and negative Patriot situations like fratricide.

PV2/TDA: I think it [provides] a great learning and teaching environment. I learned more here in two weeks than in most of AIT. It was fun yet very productive—good people, great teaching, and good tools. Should be put in all Patriot batteries for further teaching and learning.

CW3/TD: Very useful tool for S/I and Tab learning. Useful for maintaining crew proficiency. Good for giving classes and showing what is being taught to large groups. Another tool for crews to training and get familiar with the system.

CW3/TD: Great training tool. Training with RTOS resulted in increased system knowledge and understanding. Needs to support training of complete crews—incorporate 25F and communications.

SPC/TDA: Environment conducive to giving FUs situation awareness (ICC sit display on projector). I think it should be at the battery level for system knowledge and low intensity air battles. Screens seem to get too cluttered for high intensity.

PV2/TDA: I liked it. I got what the FU and ICC go through. Need more commo realism—but if it did that it wouldn't be as informational as it is. Talk between FU and ICC in the same room.

PV2/14E: It was a well constructed program and system, and I hope that I can have more work with it. I definitely learned new things and gained more information, and I just left the AIT environment. Need to add fix or fight decision making and FUFU operations.

PFC/TDA: Very good training tool.

SSG/14E: Good and could be a useful training tool at the battalion or battery level to training soldiers with a different perspective than the PCOFT or in Van by yourself.

SPC/TCA: Isolated training (the ARM Classification and JEZ-MEZ-FEZ modules) excellent. Outstanding training system.

2LT/14E: Good training tool. Gives batteries greater access to hands-on practice as well as ability to accentuate training lessons immediately after a verbal class.

SPC/14E: Train units at least every other day to make all units battle ready.

SPC/14E: Good for training—no need to set up.

SPC/TCA: Minus some minor system glitches, the system is very useful and would be a very valuable asset.

2LT/TCO: I like it! It would be better than the PCOFT. I think it would be helpful at the battery level.

SPC/TCA: Good system—great training tool.

2LT/TCO: This was excellent training because the focus was on training and not on evaluating. We were allowed to ask as many questions as we could ask and there were plenty of people to give an answer. The hands-on is the best method of learning, but it is much better when you have a presentation precede it the way it was done here. I hope to see the RTOS in the near future as part of the unit’s equipment. It will facilitate training as often and as simple as possible. For once we can focus on actual training and not on passing “spinning wheels” (an 11th ADA Brigade term which means they are doing an in depth preparation for a certain event usually a table certification). Our job is air battles and not mechanics.

2LT/TCO: I believe the RTOS system is the ideal place to teach additional skills and info (initially). Once crews have been exposed to it, they should refine it in the van.

2LT/TCO: Should have somebody knowledgeable by the TCOs and TCAs position to help mentor and coach them during the decision making process throughout the air battles. That way we can see what we are doing right and wrong. I think the RTOS is a very complete program and covers all aspects of the ECS. A good thing is that you have the ICC right there answering the TCO’s questions.

2LT/14E: The specified tasks, scenarios and training prior to and during RALs (scenarios) were very useful. I felt I had a better understanding of my purpose and understand the situation, threat, and capabilities of the system better now. We need to do some ACO (Airspace Control Order) training.

PV2/TCA: I liked the hands-on training. I think it would be priceless to have one at the battery level.

SSG/14E30: This system would be good training at the platoon level.

2LT/TCO: It was good in all areas. I think it’s better than the PCOFT.

2LT/14A: Good training. Helps before going to the van.

SGT/14E: Great tool for training.

SPC/14E: A few glitches, but is a good training device.

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